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In this research project, we developed, refined, and demonstrated both the reliability and validity (for predicting individual differences in complex task performance) of a set of perceptual speed ability tests. These tests are fully computerized and can be administered with off-the-shelf PCs. The individual tests are short (each test requires only a few minutes to administer), and are robust to differential strategies of speed or accuracy emphasis. With the existing software platform, the tests can be modified with little effort (which with further development, could be modified in real-time), to avoid any problems associated with repeated assessments or test practice. The measures demonstrate substantial incremental validity, over and above the kind of extant tests of cognitive and intellectual abilities that underlie the standard selection measures used by the U.S. Air Force. Further exploration of these tests, or tests similar to those developed in this project, is highly recommended for ultimate adoption in the operational selection environment.

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Summary

The research project was aimed at three broad approaches to development and evaluation of new methods to assess perceptual speed abilities: The first approach expands the previous research on perceptual speed abilities to consider the benefits of practice and skill acquisition for refined assessment of asymptotic perceptual speed abilities and evaluate the role of interindividual and intraindividual differences in speed-accuracy tradeoff within assessment of perceptual speed abilities. The second approach takes advantage of computerized devices for assessment of a series of perceptual speed abilities, especially with the investigation of alternative display and input devices (e.g., touch-sensitive computer monitors). The third approach evaluates the new test procedures with respect to two important validation criteria: (a) comparison with extant measures of abilities (including measures of working memory, general ability, and psychomotor abilities); and (b) an evaluation of the efficacy of perceptual speed ability measures for predicting individual differences in task performance. The goal of this work has been to demonstrate the feasibility of using new techniques and technology for assessment of perceptual speed abilities, to provide an integrated approach with psychomotor and cognitive abilities, and to demonstrate the validity of new measures of perceptual speed abilities for prediction of criterion task performance. In this context, we developed, refined, and demonstrated both the reliability and validity of a set of perceptual speed ability tests. These tests are fully computerized and can be administered in an off-the-shelf PC computer environment. The individual tests are short (each test requires only a few minutes to administer), and are robust to differential strategies of speed or accuracy emphasis. With the existing software platform, the tests can be modified with little effort (which with further development, could be modified in real-time), to avoid any problems associated with repeated assessments or test practice. The measures demonstrate substantial incremental validity, over and above the kind of extant tests of cognitive and intellectual abilities that underlie the standard selection measures used by the U.S. Air Force. Further exploration of these tests, or tests similar to those developed in this project, is highly recommended for ultimate adoption in the operational selection environment.

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I. Introduction

This project involves the continuation of a line of theoretical and empirical research that will always be of great importance to the optimal functioning of the U.S. Air Force, namely the measurement of abilities that are of critical importance for skill learning, both at initial phases of training, and later on-the-job performance. This has been a central issue for selection, training, and classification purposes, even before formal the existence of a separate U.S. Air Force (e.g., the extensive work conducted by the U.S. Army Air Forces Aviation Psychology Research Program, under the direction of John Flanagan (see Flanagan, 1948; Guilford & Lacey, 1947; Melton, 1947). Over the past 60 or so years, efforts have been devoted to developing and validating taxonomic representations of cognitive and intellectual abilities. However, more research is still needed, given the complexity of human cognitive processes, and the limited resources that have been available for their investigation. The current effort has focused on one major area of human capabilities -- perceptual speed abilities -- that have received relatively little research attention, but have been shown to account for substantial variance in the performance of complex skill tasks, where speed and accuracy of responding are critical for success.

From the 1970s through the 1990s, the dominant theme in the assessment of individual differences in abilities research has been an adaptation of the "information-processing approach." This approach to abilities research started with the work by Hunt and his colleagues (Hunt, Frost, & Lunneborg, 1973), followed by Sternberg (1977), Carroll (1980), and culminated in the large-scale studies under the Learning Abilities Measurement Program (LAMP) at the Air Force Research Laboratory (e.g., see Kyllonen, 1985, 1991; Kyllonen & Christal, 1989; -- see also Carroll, 1993 for an extensive review). While these research efforts have added substantially to the corpus of literature on the taxonomic nature of human abilities, it may be argued that in the aggregate, these efforts have not substantially enlarged the extant measures for selection and classification of entry-level recruits (namely, the ASVAB), which are dominated by an assessment of general ability (*g*) (e.g., see Olea & Ree, 1994; Ree & Earles, 1991). Little additional predictive validity is likely to be obtained by developing improved assessments of *g*, or working memory (for discussions of working memory and other abilities, see Baddeley, 1986; Cantor, Engle, & Hamilton, 1991; Engle, et al., 1999; Kyllonen & Christal, 1990). Similarly, little gain in predictive validity is expected from inclusion of measures of basic information processing (Ackerman, 2000; Carroll, 1980, 1993). However, there are two additional domains of human ability assessment that have shown promise for improving prediction of individual differences in performance, discussed in turn below.

The first domain concerns assessment of psychomotor abilities (e.g., Ackerman & Cianciolo, 1999, 2000; Kyllonen, 1994). This research has suggested that psychomotor abilities measures may yield substantial incremental validity for predicting individual differences in skill acquisition and task performance. From a pragmatic perspective, there remain issues of the feasibility of incorporating psychomotor ability measures into large-scale testing programs -- mainly because of the need for computers for administration purposes.

While the initial research has been promising, additional research is needed to hone the measures of psychomotor abilities, with a view toward implementation.

The second domain which appeared highly promising, is the area of perceptual speed ability assessment. In previous AFOSR-sponsored research (e.g., Ackerman, 1999), taxonomic theoretical developments and empirical research have converged on a multiple factor representation of perceptual speed abilities. This research has further demonstrated that there is indeed much promise in using selected perceptual speed ability measures in predicting individual differences in skill acquisition and task performance. The current research project concerned the further exploration of the perceptual speed ability domain, and has as a major goal the demonstration of the feasibility of perceptual speed ability assessments within both paper and pencil and computerized frameworks.

Specific Background

The term "perceptual speed ability" is somewhat of a misnomer, from the perspective of experimental psychology, because perceptual speed tests involve all phases of information processing, from encoding, perception, central processing/working memory, response selection and execution. At the most general level, what characterizes perceptual speed tests (Ackerman & Cianciolo, 2000) is that test items are relatively simple -- examinees are able to correctly respond to each item without error in untimed testing. Rather, the key to performance on each such test is the speed and accuracy of responding. The Armed Services Vocational Aptitude Battery (ASVAB) contains two tests that at least partly tap aspects of perceptual speed, namely Code Speed and Numerical Operations. These tests, though, appear to barely scratch the surface of the underlying construct. From our taxonomic research, we suspect that these are not optimal tests for a variety of application purposes.

While there have been many so-called perceptual speed ability assessments developed over the past 80 years or so, the nature of such factors has been largely unexplored. Carroll (1993, p352), for example, in his review of the corpus of human cognitive abilities only reports a few limited studies, and suggested that "*as far as can be determined from the data* [test design differences] do not make for systematic differences in factor loadings." Until our recent AFOSR-sponsored research, there has only been one large-scale investigation into perceptual speed abilities -- namely, the work of Guilford and his colleagues in the U.S. Army Air Forces Aviation Psychology Research Program (Guilford & Lacey, 1947). While that research program was highly productive in developing selection tests for pilots, navigators and gunners, very little taxonomic work was reported from those investigations. Rather, when a test was developed that showed an improvement in predicting training success, it was rapidly incorporated into the selection and classification program. For example, the Dial and Table Reading test was found to be the most effective test for selection of pilots (Guilford & Lacey, 1947, p. 403). Subsequent research, by the Federal Aviation Administration Civil Aeromedical Institute (Cobb & Matthews, 1972; Sells, et al., 1984) found the Dial and Table Reading Test and a similar test to be highly effective in predicting training success of civilian air traffic controllers. For somewhat obscure reasons, the U.S. Air Force dropped the use of

this test shortly after World War II, and the FAA discontinued research on the test after a single study.

Our research (e.g., Ackerman & Kanfer, 1993a; Ackerman, Kanfer, & Goff, 1995) has documented that the Dial Reading Test is both highly predictive of individual differences in performance during complex skill acquisition, both in the laboratory and in job selection -- largely supportive of the research from the AAF and FAA programs. (It may be useful to note that Ackerman & Kanfer [1993b] developed a parallel version of the Dial Reading Test, and it remains one of the most effective tests in the battery we developed for the Minnesota Air Traffic Control Training Center [a regional facility sponsored by the FAA].) Our more recent research has focused on the taxonomic underpinnings of the test, along with a series of other perceptual speed tests, with an aim to developing a framework for the exploration and specification of the sphere of perceptual speed abilities. From this work, the Dial Reading Test has been shown to be an excellent marker for Perceptual Speed (PS)-Complex ability, one of four factors underlying the larger domain of perceptual speed.

Structure of Perceptual Speed Abilities

In a previously completed AFOSR-sponsored research project (Ackerman & Cianciolo, 2001, 2002), we created an augmented battery of perceptual speed ability measures that was predicated on a taxonomic approach to the ability construct. Fifteen new tests were developed that represented different contents (verbal, spatial, numerical), different levels of consistency of stimuli, and different levels of stimulus familiarity. In addition, six extant measures of perceptual speed ability were administered to provide for calibration with the wider research literature, along with measures of general and broad content cognitive abilities. At one level, this research demonstrated that there is significant common variance among perceptual speed ability measures. At a more fine-grained analysis, the results indicated that there are at least three identifiable perceptual speed factors, which we named "PS-Pattern Recognition," "PS-Scanning," and "PS-Memory." As discussed above (see also Ackerman et al., 1995), we determined that there also existed a 'complex process' perceptual speed ability, which we identified as PS-Complex.

Ability Determinants of Individual Differences in Skill Acquisition

In previous research, we have made substantial progress in first proposing, then empirically validating a theoretical approach to the ability determinants of individual differences in performance during skill acquisition (e.g., Ackerman, 1988, 1990, 1992, 2000; Ackerman et al., 1995). In the most recent investigations (Ackerman & Cianciolo, 2000, 2002) we have expanded the foundation of ability measures to include a selection of psychomotor ability measures (e.g., Serial RT, Maze Tracing, Mirror Tracing, Pursuit) using a specially designed software suite for test administration and PCs with touch-sensitive computer monitors. Initial validation efforts with a full set of ability measures (verbal, spatial, numerical, perceptual speed, and psychomotor) have supported, in particular, the incremental predictive validity of perceptual speed and psychomotor measures, especially in predicting individual differences in performance at intermediate and highly practiced levels of performance.

Other research in this field has demonstrated that prediction of individual differences in performance during skill acquisition and at asymptotic levels of performance can be significantly and substantially improved (e.g., Ackerman & Kanfer, 1993a, 1993b; Ackerman & Cianciolo, 1999, 2001). By building on the foundation of general and broad content cognitive abilities (e.g., verbal, spatial, numerical), properly selected measures of perceptual speed and psychomotor ability measures may be used to enhance selection procedures and to identify individuals who are more likely to succeed or fail during training or skill acquisition practice. While there is an extensive corpus of empirical research on the general and broad content abilities, additional exploratory and confirmatory research is needed in the perceptual speed ability domain. Moreover, to integrate perceptual speed abilities into the larger consideration of abilities, additional research is needed to establish how particular aspects of perceptual speed abilities relate to cognitive and psychomotor abilities, and to establish how these abilities relate to skill-learning task performance criteria. The experiments described below represented an in-depth pursuit of these construct and criterion-related validation goals for perceptual speed abilities.

II. Current Research

Critical Abilities for Performance

In the current research project, and based on our previous AFOSR-sponsored research (Kanfer & Ackerman, 1990; Ackerman & Kanfer, 1996; Ackerman, 1999), we have developed theory and conducted extensive empirical research with an aim toward developing a useful classification of abilities that are critical for the prediction of individual differences in performance during and after skill acquisition. In concert with other U.S. Air Force research (e.g., Kyllonen, 1985, 1994; Woltz, 1988) and the extant literature on human abilities (e.g., see Carroll, 1993), we have identified several key ability classes that have been demonstrated to have substantial validity for predicting individual differences in performance on skill-learning tasks. Each of these abilities is briefly discussed below.

General/Content Abilities. General intellectual abilities have perhaps the most substantial basis for predicting individual differences in learning tasks -- starting with the early research of Binet & Simon (1905) regarding the prediction of academic performance. Initial research and theory (e.g., Spearman, 1904) suggested that general intelligence was amorphous and indivisible. However, by the 1920s and 1930s, it had been clearly established that general intelligence was not all-encompassing in terms of either basic underlying individual differences (e.g., see Kelly, 1928; Thomson, 1939; Thurstone, 1938), or in terms of building optimal models for predicting performance in specific domains. So-called "group factors" or "content abilities" (e.g., spatial, math, verbal) were reliably found when large batteries of ability tests were subjected to factor analysis. Moreover, examination of these content factors revealed that validity in predicting individual differences in performance depended in part on a match between the content of the predictor ability and the content of the criterion task. That is, when trainees were required to learn highly-spatially demanding tasks or jobs, tests of spatial ability were generally more highly correlated with criterion task

performance than were, say, verbal ability measures (e.g., see Guilford & Lacey, 1947).

It is possible to identify dozens of group factors, but as shown by Snow, Kyllonen, and Marshalek (1984), dividing the ability sphere into Spatial, Math, and Verbal abilities is a valid simplification for categorization purposes. In addition, this breakdown of the structure of abilities provides a simplifying scheme that can be adapted to particular broad-based prediction paradigms (when the researcher wishes to generalize beyond a narrow range of criterion tasks). We refer to these categories as content factors, because at least on a surface-level analysis of task requirements, the content of the tests describes the stimuli upon which the individual must work with to solve the test problems (i.e., words for Verbal content, figures for Spatial content, and numbers for Math content)

A final general ability has also been subjected to a great amount of discussion in the past 10 years or so. In one framework Working Memory (a construct from the experimental psychology literature) can be thought of as attentional capacity (e.g., see Baddeley, 1986). Recent discussion has also portrayed working memory as essentially the same thing as reasoning ability -- which is central to the conceptualization of general intelligence (over and above respective content abilities), see Kyllonen & Christal (1989, 1990). Working Memory has been implicated as critical for predicting individual differences in task performance, especially on complex tasks. As such, a consideration of Working Memory, as a supplement to the content factors is being incorporated into two of the empirical studies described below.

Perceptual Speed Abilities. Previous research in our laboratory has demonstrated that perceptual speed abilities may provide a critically important supplement to measures of general and broad content abilities, in the prediction of individual differences in performance during skill acquisition (e.g., Ackerman, 1988; 1990; 1992; Ackerman & Kanfer, 1993; Ackerman, Kanfer & Goff, 1995). According to Ackerman (1988), Perceptual Speed (PS) is defined as: "In the language of skill acquisition, individual differences found on [perceptual speed] tests are directly attributable to the speed with which these productions can be implemented and compiled (e.g., see Werdelin & Stjernberg, 1969). (p. 190)" It turns out that a more extensive analysis of extant measures of PS ability suggested that the tests could be taxonomized on a number of (overlapping) dimensions, based on an information-processing analysis of test content. A previous analysis (Ackerman & Rolhus, 1996) suggested the following candidate dimensions of underlying test demands: (a) Content (spatial, verbal, numerical), (b) Consistency (consistent information processing or varied information processing); (c) Novelty (familiar vs. novel stimuli); (d) Precision (of encoding and of responding); (e) Modality (of encoding and of responding); (f) Memory demands (low vs. high), (g) Scanning vs. single items.

While it would be theoretically possible to create a completely-crossed sampling of tests for these seven dimensions, the exponential number of tests that would be generated make for an impractical empirical evaluation (especially inasmuch as tests could also combine dimensions -- such as a test that had mixed spatial and verbal content). Instead, in Ackerman & Cianciolo (2000) we attempted to sample broadly from most of these dimensions, in the

hope that patterns of consistent individual differences would emerge, inductively, across the various dimensions. In all, we adapted or created 15 tests of PS abilities, to administer along with 6 extant measures of PS abilities, 12 tests of content abilities (verbal, spatial, numerical), and a set of Choice and Simple RT measures.

By subjecting the PS tests to a factor analysis, we established that there is a general PS factor, but there were also three lower-order PS factors that were clearly differentiable in terms of the information processing demands of the tests. Specifically, one factor was dominated by tests that involved recognition of simple patterns (e.g., Canceling Symbols and Finding € and ¥) -- which we designated as PS-Pattern Recognition (abbreviated PS-Pattern). A second factor involved scanning, comparison, and look-up processes (e.g., Name-Comparison Test and Number Comparison Test), which we designated as PS-Scanning. The third factor was best identified as making substantial demands on working memory (e.g., Digit/Symbol, and Coding tests). We identified this factor as PS-Memory. A complete representation of PS ability also includes an additional PS factor identified in previous research (called PS-Complex, because the tests involve both traditional PS and additional cognitive components, such as spatial ability and estimation/interpolation, and heightened working-memory loads; see Ackerman, Kanfer, & Goff, 1995). This factor structure was replicated in a later study (also reported in Ackerman & Cianciolo, 2000).

Based on our research, these four PS factors (PS-Complex, PS-Memory, PS-Pattern, and PS-Scanning) have differential associations with task performance across skill acquisition trials. Some (e.g., PS-Complex and PS-Memory) are especially important in accounting for individual differences in performance on complex skill tasks, while others (PS-Pattern and PS-Scan) are more important in accounting for individual differences in performance on simple skills.

Psychomotor Abilities. Although new developments are not considered for the empirical studies described below, our research has shown that there psychomotor ability measures can also provide incremental predictive validity for individual differences in skilled performance -- especially for tasks that are routine and proceduralized (see, e.g., Ackerman & Cianciolo, 1999; 2000). Ability factors for Tapping, Mirror and Maze Tracing, and for Serial Reaction Time have been reasonably well established as useful predictors after extensive task practice.

Experiments Conducted

Five major experiments were conducted in the context of this research project. Each is briefly described below.

Experiment 1. The first study in this project was devoted to validating the underlying nomothetic construct space for perceptual speed abilities, using existing paper and pencil tests. In addition, we added an assessment of several measures of working memory abilities, to better integrate the current constructs with those that have been proposed to be integral to the assessment of general intelligence. The basic goals of the study were accomplished

(validating the construct space of perceptual speed abilities). From a scientific perspective, this research also demonstrated that measures of working memory are highly correlated with perceptual speed abilities. The experiment is described in: Ackerman, P. L., Beier, M. E., & Boyle, M. O. (2002). Individual differences in working memory within a nomological network of cognitive and perceptual speed abilities. *Journal of Experimental Psychology: General*, 131, 567-589.

Abstract

It has become fashionable to equate constructs of working memory (WM) and general intelligence (or *g*). Few investigations have provided direct evidence that working memory and *g* measures yield similar ordering of individuals. Correlational investigations have yielded mixed results. We assess the construct space for working memory and *g*, and demonstrate that WM shares substantial variance with perceptual speed (PS) constructs. Thirty-six ability tests representing verbal, numerical, spatial and PS abilities, the Raven test, and seven WM tests were administered to 135 adults. A nomological representation for working memory is provided through a series of cognitive and PS ability models. In addition, construct overlap between PS and WM is further investigated with attention to complexity, processing differences, and practice effects. (Ackerman, et al., 2002; p. 567).

Experiment 2. The second experiment in the research project was devoted to a try-out of the first set of computerized perceptual speed tests (those involving single stimulus presentation). Ten new computerized tests were created (Name Comparison, Divide-by-7, Digit-Symbol, Number Comparison, Coding, Sum-to-10, Directional Headings, CA-2, Letter/Number Substitution, and Naming Symbols). The tests were administered with two sessions (for assessment of test-retest reliability), along with parallel paper and pencil versions of the same tests (for the assessment of alternate form reliability), and with a series of cognitive ability measures. A sample of 167 college students participated in the experiment. Test-retest reliability estimates were substantial, especially given that the computerized perceptual speed tests are short and highly speeded. Test-retest reliability estimates ranged from $r = .72$ to $.84$, with a mean of $.79$. As expected, alternate form reliabilities were smaller than test-retest reliabilities, but were quite reasonable in magnitude, indicating that the computerized and paper and pencil measures were assessing broadly the same underlying constructs. The range of alternate form reliabilities was $.45$ to $.78$, with a mean of $.62$.

Experiment 3. The third experiment in the research project was designed to assess the role of speed-accuracy tradeoff instructions on performance on the new computerized perceptual speed ability measures. A sample of 164 college students were first administered six computerized perceptual speed tests under standard instructions, followed by administrations with either speed emphasis or accuracy emphasis (under a counterbalanced order design). Mean performance under the speed and accuracy conditions indicated that the participants were generally capable of changing their performance strategies to reflect the change in speed-accuracy emphasis, in terms of changes to number correct responses and number of errors. Most significant were the robust correlations between individual differences in performance across the two conditions. Speed and accuracy condition performance levels

correlated from .51 to .68 for the six tests, with a mean correlation of $r = .63$. In addition, by applying a standard penalty for errors to both conditions resulted in relatively little differences in mean overall performance for the computerized perceptual speed tests, suggesting that the tests provide robust estimates of ability, even under differing emphases for speed or accuracy of performance. Results of this study, with attention to gender differences in performance under the different conditions were presented at the 2003 American Psychological Society annual meeting: Boyle, M., Beier, M. E. & Ackerman, P. L. (May, 2003). *Speed-accuracy tradeoff, test performance and gender*. Poster presented at the annual convention of the American Psychological Society. Atlanta, GA.

Experiment 4. This study was designed to try-out the second set of computerized perceptual speed tests -- those that involve screens with multiple stimuli (e.g., where the examinee searches a display for a stimulus that fits a certain criterion, such as words with both an 'a' and a 't' in them). The study involved 160 college student participants, who were administered six new computerized perceptual speed tests (Canceling Symbols, Finding a/t, Summing-to-10, Scattered Xs, Factors of 7, and Finding € and ¥). As with the previous experiments, the new tests were administered in a test-retest format, along with various paper and pencil (and computerized) reference tests. Results from this experiment indicated that these new tests had reliabilities of the same range as the single-stimulus item tests.

Experiment 5. The final study in this project aimed to integrate the previous development of computerized perceptual speed tests with extant cognitive ability measures, in an effort to determine the independent and incremental criterion-related validity of these measures of performance of complex skill acquisition tasks. Fourteen computerized perceptual speed tests (both single-stimulus and multiple-stimulus tests) were administered, along with a battery of twelve cognitive ability measures and five psychomotor ability tests. Skill acquisition practice was provided on two criterion tasks -- 28 ten-minute trials for the Kanfer-Ackerman Air Traffic Controller Task (K-A ATC) (e.g., see Kanfer & Ackerman, 1989) and 15, thirty-minute trials for the high-fidelity Terminal Radar Approach Control (TRACON) simulation task (e.g., see Ackerman, 1992). A sample of 117 college students participated in the study. Data analysis is continuing, but preliminary results indicate that the new computerized perceptual speed ability measures accounted for 12.6% of the variance in final skilled performance in the K-A ATC task, and 28.7% of the variance in final skilled performance on TRACON, the more complex criterion task. In conjunction with the other reference ability measures, we were able to account for a total of 40.0% of the variance in final K-A ATC task performance, and 38.9% of the variance in final TRACON performance. These results clearly indicate that efficacy of the new perceptual speed measures for enhancing the prediction of individual differences in complex task performance.

Conclusions/Recommendations

Given the large investment made in both selection and training of U.S. Air Force personnel, improvements to the accuracy of prediction of individual differences in performance (especially those that are substantially cost-effective) seem to present an opportunity for further research and implementation in the operational environment. In this

research project, we have developed, refined, and demonstrated both the reliability and validity (for predicting individual differences in complex task performance) of a set of perceptual speed ability tests. These tests are fully computerized and can be administered in an off-the-shelf PC computer environment. The individual tests are short (each test requires only a few minutes to administer), and are robust to differential strategies of speed or accuracy emphasis. With the existing software platform, the tests can be modified with little effort (which with further development, could be modified in real-time), to avoid any problems associated with repeated assessments or test practice. The measures demonstrate substantial incremental validity, over and above the kind of extant tests of cognitive and intellectual abilities that underlie the standard selection measures used by the U.S. Air Force. Further exploration of these tests, or tests similar to those developed in this project, is highly recommended for ultimate adoption in the operational selection environment.

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III. Personnel

The following personnel had significant involvement in this research effort:

Ackerman, Phillip L.; Principal Investigator

Beier, Margaret E.; Research Assistant/Associate

Bowen, Kristy, Research Assistant

Boyle, Mary O. (Purdue); Research Assistant

Hocking, Kellie; Laboratory Coordinator

Kantrowitz, Tracy; Research Assistant

Ko, Emily; Research Assistant

Kanfer, Kanfer, Professor

Pearson, Kim; President, New Boundary Technologies, Software Development

IV. Publications during the grant period and "in press"

Ackerman, P. L. (2001). Adult intelligence from knowledge and trait complex perspectives.

In R. K. Silbereisen and M. Reitzle (Eds.) *Bericht über den 42. Kongreß der Deutschen Gesellschaft für Psychologie in Jena 2000*. (pp. 57-64.) Berlin: Pabst.

Ackerman, P. L. (2001). Review of *START: Strategic Assessment of Readiness for Training*.

In J. Impara (Ed.), *The fourteenth mental measurements yearbook* (pp. 1179-1180). Highland Park, NJ: Gryphon Press.

Ackerman, P. L. (2001). Review of *The Attentional and Interpersonal Style Inventory*. In J.

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look at achievement score differences? *Issues in Education: Contributions from Educational Psychology*, 8(1), 21-29.

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memory within a nomological network of cognitive and perceptual speed abilities. *Journal of Experimental Psychology: General*, 131, 567-589.

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complex task performance. *Journal of Experimental Psychology: Applied*, 8(3), 194-208.

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look at achievement score differences? *Issues in Education: Contributions from Educational Psychology*, 8(1), 21-29.

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- Ackerman, P. L. (2003). Aptitude complexes and trait complexes. *Educational Psychologist*, 38, 85-93.
- Ackerman, P. L. (2003). Cognitive ability and non-ability trait determinants of expertise. *Educational Researcher*, 32(8), 15-20.
- Ackerman, P. L. (2003). Review of *d2 Test of Attention*. In B. S. Plake, J. C. Impara & R. A. Spies (Eds.), *The fifteenth mental measurements yearbook* (334-335). Highland Park, NJ: Gryphon Press.
- Ackerman, P. L. (2003). Review of *Space Relations (Puzzle Pieces)*. In B. S. Plake, J. C., Impara & R. A. Spies (Eds.), *The fifteenth mental measurements yearbook* (844-845). Highland Park, NJ: Gryphon Press.
- Ackerman, P. L., & Beier, M. E. (2003). Intelligence, personality, and interests in the career choice process. *Journal of Career Assessment*, 11(2), 205-218.
- Ackerman, P. L., & Beier, M. E. (2003). Trait complexes, cognitive investment and domain knowledge. Chapter in R. J. Sternberg & E. L. Grigorenko (Eds.), *Perspectives on the psychology of abilities, competencies, and expertise*. (pp. 1-30). NY: Cambridge University Press.
- Ackerman, P. L. & Lohman, D. F. (2003). Education and g. Chapter in H. Nyborg (Ed.). *The scientific study of general intelligence -- Tribute to Arthur R. Jensen* (pp. 275-292). Amsterdam: Pergamon/Elsevier Science.
- Beier, M. E., & Ackerman, P. L. (2003). Determinants of health knowledge: An investigation of age, gender, abilities, personality, and interests. *Journal of Personality and Social Psychology*, 84 (2), 439-448.
- Ackerman, P. L. (in press). Ability determinants of individual differences in skilled performance. To appear in Sternberg, R. J., & Pretz, J. (Eds.) *Cognition and Intelligence: Identifying the Mechanisms of the Mind*. Cambridge University Press.
- Ackerman, P. L. (in press). Personality, trait complexes, and adult intelligence. To appear in A. Elias, S. Hampson, & B. de Raad (Eds.) *Advances in Personality, Volume II*. Psychology Press.
- Ackerman, P. L. (in press). Remembrance of Lloyd G. Humphreys. To appear in *American Psychological Society "Observer"*.
- Ackerman, P. L. (in press). Review of *Clerical Skills Test Series*. In B. S. Plake, J. C., Impara & R. A. Spies (Eds.), *The sixteenth mental measurements yearbook*. Highland Park, NJ: Gryphon Press.
- Ackerman, P. L. (in press). Review of *Emotional Judgment Inventory*. In B. S. Plake, J. C., Impara & R. A. Spies (Eds.), *The sixteenth mental measurements yearbook*. Highland Park, NJ: Gryphon Press.

- Ackerman, P. L., & Beier, M. E. (in press). Knowledge and Intelligence. To appear in O. Wilhelm, & R. Engle (Eds.) *Recent improvements in measuring and understanding intelligence*. Sage.
- Ackerman, P. L., & Kanfer, R. (in press, 2004). Cognitive, affective, and conative aspects of adult intellect within a typical and maximal performance framework. Chapter to appear in: D. Y. Dai & R. J. Sternberg (Eds.) *Motivation, emotion, and cognition: Integrated perspectives on intellectual functioning*. Mahwah, NJ: Erlbaum. (9/02).
- Boyle, M. O., & Ackerman, P. L. (in press, 2004). Individual differences in skill acquisition. Chapter to appear in A. M. Williams, N. J. Hodges, M. A. Scott, & M. L. J. Court (Eds.) *Skill acquisition in sport: Research, theory and practice*. Taylor and Francis/Routledge.
- Kanfer, R., & Ackerman, P. L. (in press). Adult development and work motivation. To appear in *Academy of Management Review*.

V. Presentations during the grant period

- Ackerman, P. L. (2001, March). *Applying the science of learning to the university and beyond*. Invited panelist. Sponsored by American Psychological Society/Spencer Foundation; Pamona, CA.
- Beier, M. E., & Ackerman, P. L. (2001, April). *Reexamining Cloze and Completion methods*. Poster presented at the 2001 annual meeting of the American Educational Research Association, Seattle, WA.
- Beier, M. E., Bowen, K. R., & Ackerman, P. L. (2001, April). *Gender differences in ability and self-estimates of ability*. Poster presented at the 2001 annual meeting of the Society of Industrial and Organizational Psychology, San Diego, CA.
- Ackerman, P. L. (2001, June). *Trait Complexes*. Invited address presented at the Applications for New Constructs for Assessment conference. Sponsored by Educational Testing Service (ETS); Princeton, NJ.
- Ackerman, P. L. (2001, July). Discussant. *The role of individual differences with respect to medicine: Career selection, performance, and stress*. Symposium presented at the International Society for the Study of Individual Differences, Edinburgh, Scotland.
- Ackerman, P. L., Bowen, K. R., Beier, M. B., & Kanfer, R. (2001, July). *Determinants of individual differences and gender differences in knowledge*. Paper presented at the International Society for the Study of Individual Differences, Edinburgh, Scotland.
- Ackerman, P. L. (2002, March). *Trait complexes, academic success, and adult intellectual development*. Invited Keynote Address presented to the UGA Psi Chi Behavioral Sciences Convention. Athens, GA.
- Kanfer, R., & Ackerman, P. L. (April, 2002). *New directions in motivation research*. Symposium paper presented at the annual convention of the Society of Industrial and Organizational Psychology, Toronto, Canada.
- Beier, M. E., & Ackerman, P. L. (April, 2002). *Age, gender and health knowledge: Investment, experience, and trait determinants of knowledge*. Poster presented at the Cognitive Aging Conference. Atlanta, GA.

- Ackerman, P. L. (June, 2002). *Trait complexes*. Symposium paper presented at the annual convention of the American Psychological Society. New Orleans, LA.
- Ackerman, P. L. (June, 2002). Discussant for Symposium on *The role of work in successful development across the life course*. Symposium presented at the annual convention of the American Psychological Society. New Orleans, LA.
- Beier, M. E., Perdue, M. B., & Ackerman, P. L. *Working memory is highly related to perceptual speed and general intelligence* (June, 2002). Poster presented at the annual convention of the American Psychological Society. New Orleans, LA.
- Perdue, M. B., & Ackerman, P. L. *Non-ability traits provide incremental prediction of self-concept*. (June, 2002). Poster presented at the annual convention of the American Psychological Society. New Orleans, LA.
- Ackerman, P. L. (2002, July). *Intelligence, personality, and motivational determinants of knowledge: A trait-complex approach to the world of work*. Invited address presented to the International Congress of Applied Psychology. Singapore.
- Ackerman, P. L. (2002, December). *Trait complexes and adult intellectual development*. Invited address presented at a symposium titled "Future of Intellectual Assessment and Psychometrics." Vanderbilt University, Nashville, TN.
- Ackerman, P. L. (2003, May). *Cognitive investment and adult intellectual development*. Presentation for invited symposium on "Aging, Adult Development, and Work" presented at the annual convention of the American Psychological Society. Atlanta, GA.
- Boyle, M., Beier, M. E. & Ackerman, P. L. (May, 2003). *Speed-accuracy tradeoff, test performance and gender*. Poster presented at the annual convention of the American Psychological Society. Atlanta, GA.
- Ko, C-H., Kanfer, R., & Ackerman, P. L. (May, 2003). Motivational traits and self-evaluation.: Further evidence for linkages between motivation and self-evaluation. Poster presented at the annual convention of the American Psychological Society. Atlanta, GA.
- Ackerman, P. L. (May, 2003). Chair/Discussant "*Working memory and intelligence: Controversy or consensus*." Symposium presented at the annual convention of the American Psychological Society. Atlanta, GA.
- Ackerman, P. L. (2003, June). *Multitasking: Good, bad, or ugly?* Invited address presented at the SMC³ summer meeting. St. Petersburg, FL.
- Ackerman, P. L., Beier, M. B., & Boyle, M. O. (July, 2003). *Working memory within a nomological network of cognitive and perceptual speed abilities*. Symposium presentation at the International Society for the Study of Individual Differences, Graz, Austria.
- Beier, M. B., Ackerman, P. L., & Boyle, M. O. (July, 2003). *New taxonomic and assessment developments for perceptual speed abilities*. Symposium presentation at the International Society for the Study of Individual Differences, Graz, Austria.